



U.S. Army Research, Development and Engineering Command



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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US Army RDECOM ARDEC

**Chromium Elimination and Cannon
Life Extension for Gun Tubes**

**ESTCP WP-201111
ASETSDEFENSE OVERVIEW
August 30, 2012**

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Function

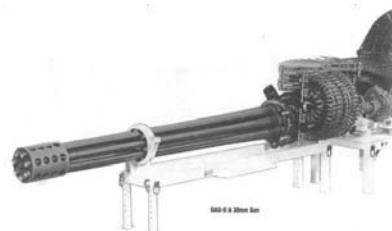
PI Program Manager
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Material Science
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Material Science
Technical Adviser
Cost Data Collection
Thermal Modeling
Explosive Analysis
Material Science
Manufacturing
Cladding Technology



Technical Objectives

- To eliminate the use of hexavalent chromium (VI) in the production of cannon barrels by developing a cost effective environmentally friendly Explosive Bonding process.
- To demonstrate and validate the effectiveness of a cannon tube explosively clad with tantalum-10 tungsten (Ta-10W) liner to decrease erosion and increase performance and extend the lifecycle.
- The baseline for testing is a chromium plated gun tube.

Technical Approach



High Rate GAU
Cannon Systems



BFV
25mm M242 Cannon



M242 Bases C-RAM

**Explosive Bonding
Technology could
potentially be used
on the following
Legacy and New
Weapons Systems
Platforms.**



Mk 38 Tactical Standoff Systems



Future GFV
30-50mm Cannons



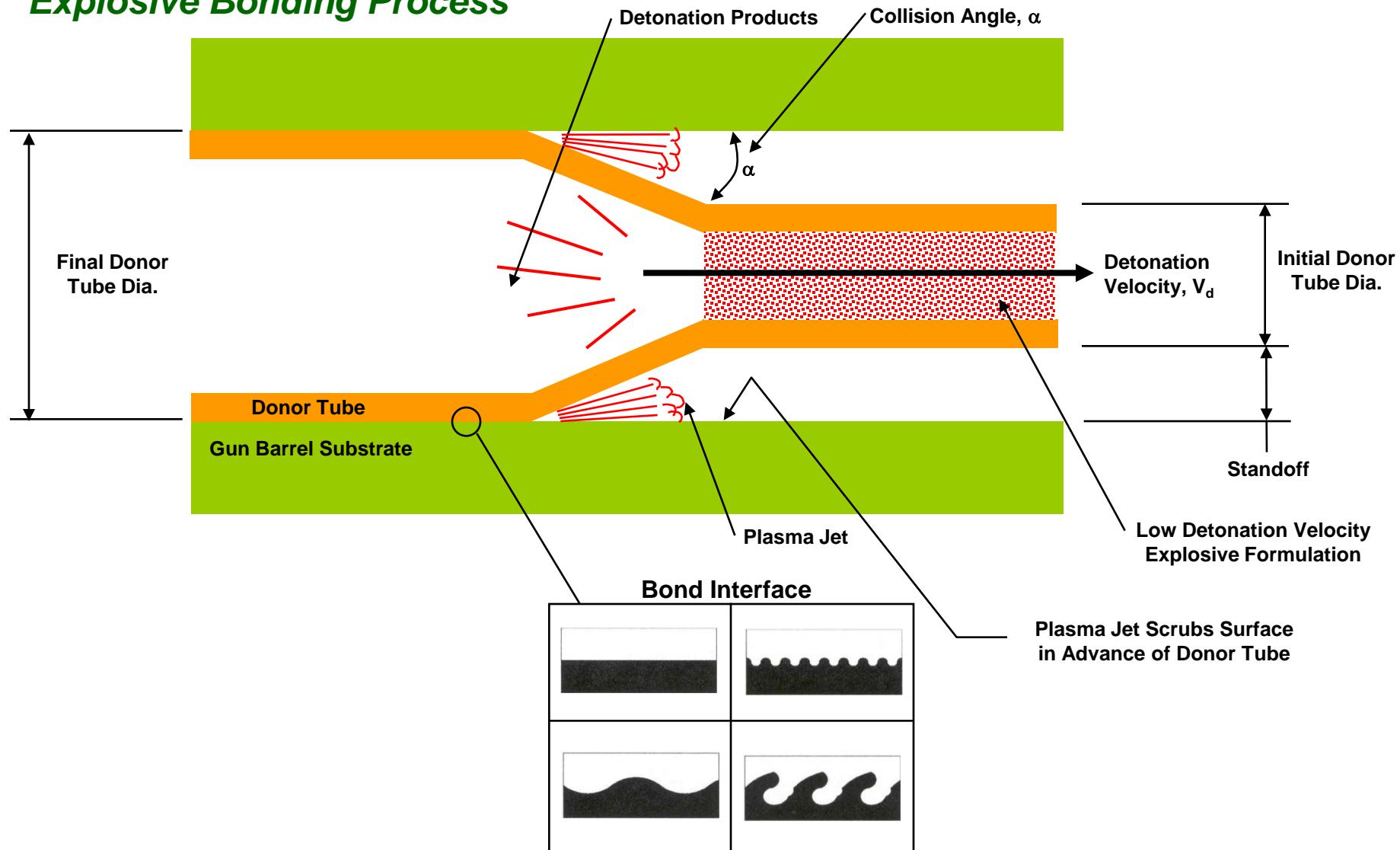
High Mobility
Weapons



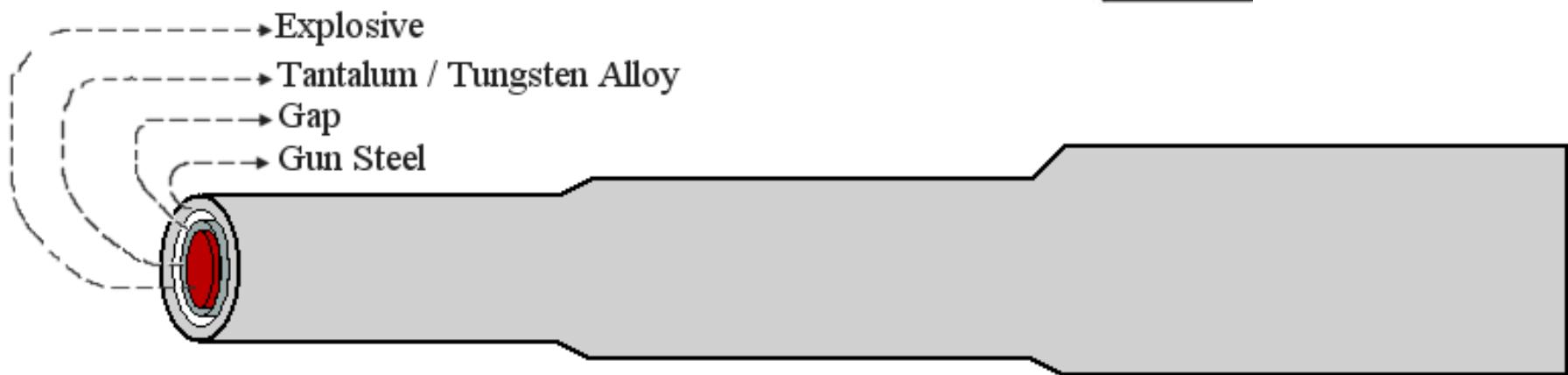
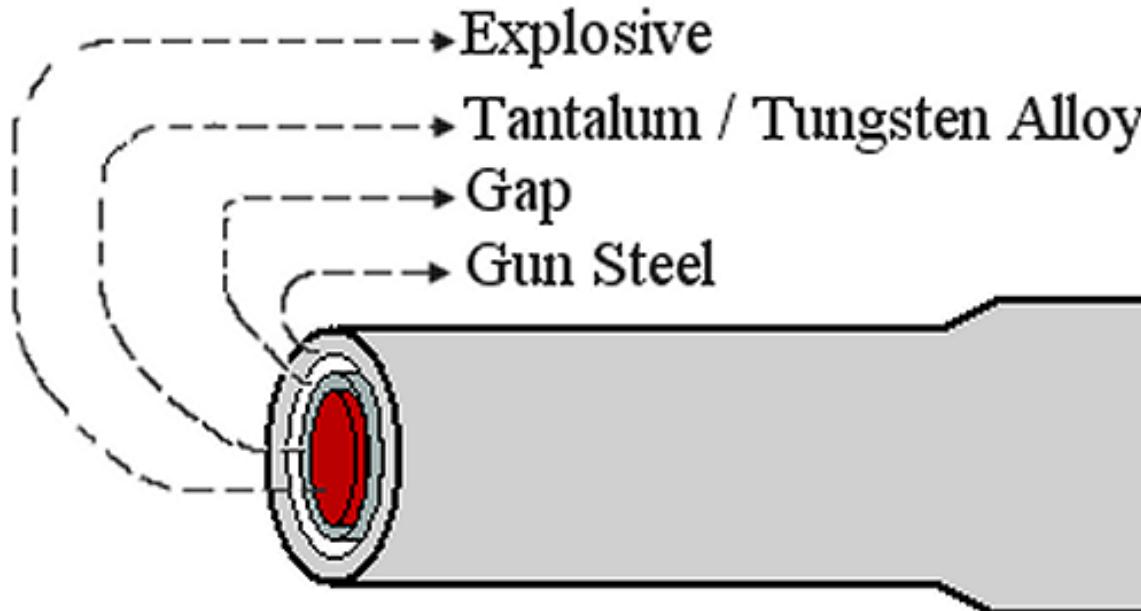
Large Caliber Recoilless
Cannon Systems

Technical Approach

Explosive Bonding Process



Explosive Bonding Process

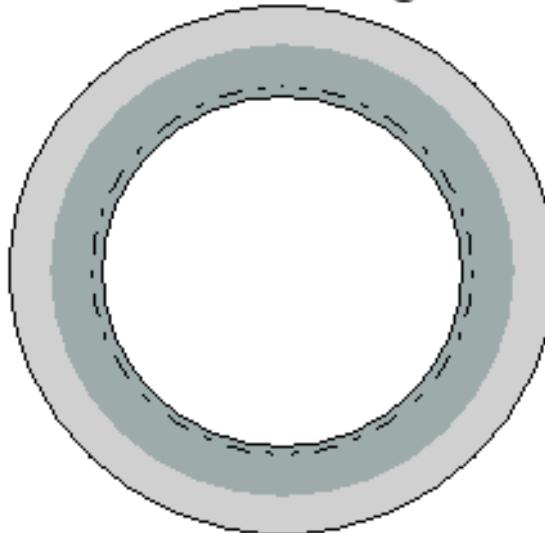


Explosive Bonding Process

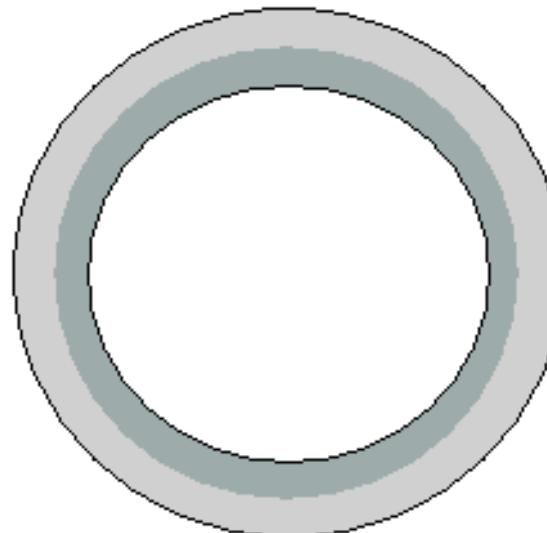


Honing & Rifling Process

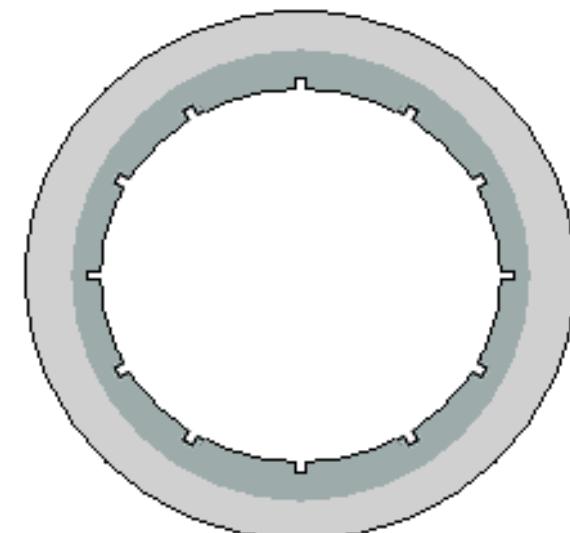
Before Honing



After Honing



After Rifling



Honing Tool



Rifling Tool



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Technical Approach



Melting Point 1857 °C

3422 °C

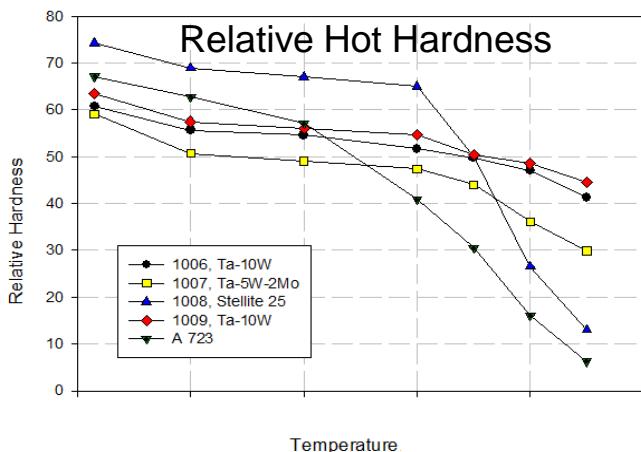
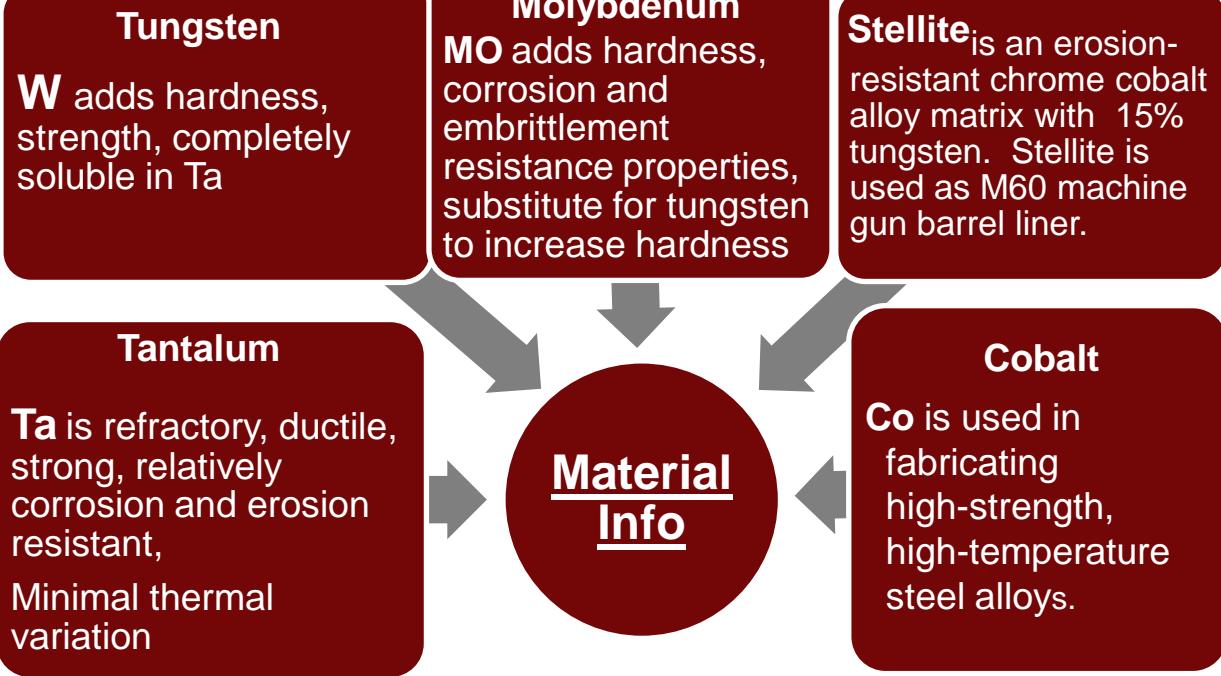
Melting Point 3017 °C

Melting Point 1495 °C

Melting Point 2623 °C

Material Selection Goals:

1. Increased surface hardness for improved wear resistance
2. Reduced chemical reactivity including hydrogen embrittlement
3. Increased erosion resistance
4. Enhanced machinability to accommodate rifling
5. Reduce interface intermetallics



Technical Approach

25 μm

Gun Steel to Ta-10W Bond Line



**Section of 18" Truncated Barrel
Ta-10W Donor Tube "Liner"**



**Sectioned 18" Truncated Barrel
Cladded with Ta-10W**



Technical Progress

Major Progress/Accomplishments 2011-2012

- **Demonstrational Test Plan for ESTCP Program WP-20111**
 - Developed, approved, and initiated
- **Firing Test Plan - JTP**
 - Developed and approved by ARDEC Medium Caliber Gun and Ammo Division
 - approved by APG
- **M242 25mm Barrels Fabricated**
 - S/N 101: Ta-10W
 - S/N 102: Ta-10W
 - S/N 103: Ta-10W
 - S/N 104: Ta-10W
- **Firing Test Conducted at YPG - High Energy Ammo Tests**
 - SN101 Ta-10W - using M919 and M791
 - SN7039 - using M919 and M791
- **Develop Advanced NDT Techniques for Weapon Systems**
I E. :UT CSCAN, CT-XRAY, 3D Measurements, EBIS

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Demonstration Site: Yuma Proving Grounds (YPG)

Preliminary proof of principle endurance testing at YPG shows promising results when conducted side by side to a chrome plated barrel.

The chrome barrel was condemned at 3,650 rounds.

At more than 12,000 rounds the Ta-10W tube.

The chamber was shown to be less than 1/3 worn when compared to the condemned chrome barrel.

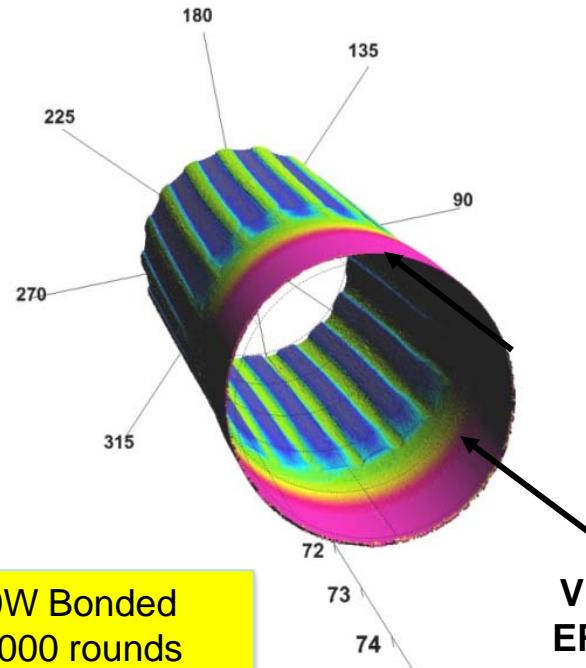
Virtually no wear on the tubes lands.



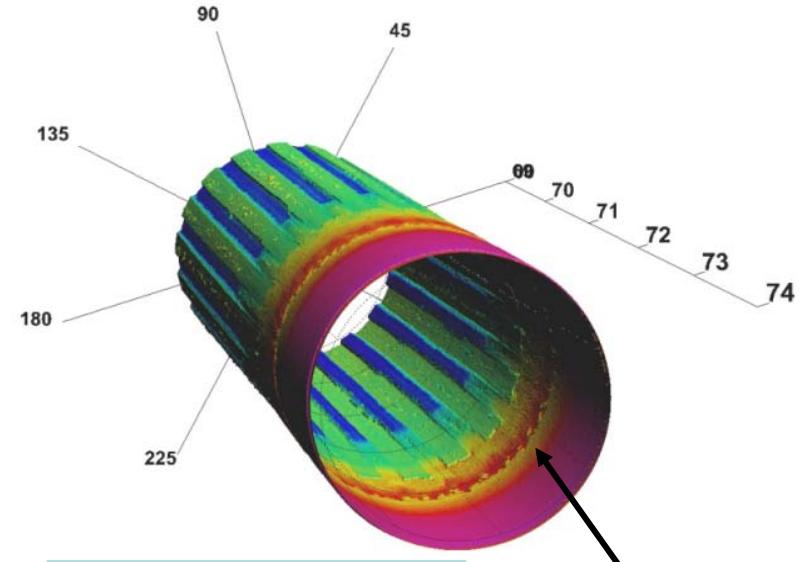
**Endurance Testing GP-20
Medium Caliber Range YPG**
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Overview of Prior Work

25mm M242 Barrel Ta-10W EB Liner Proof-of-Principle Testing



VIRTUALLY NO EROSION ON ID OF GUN STEEL

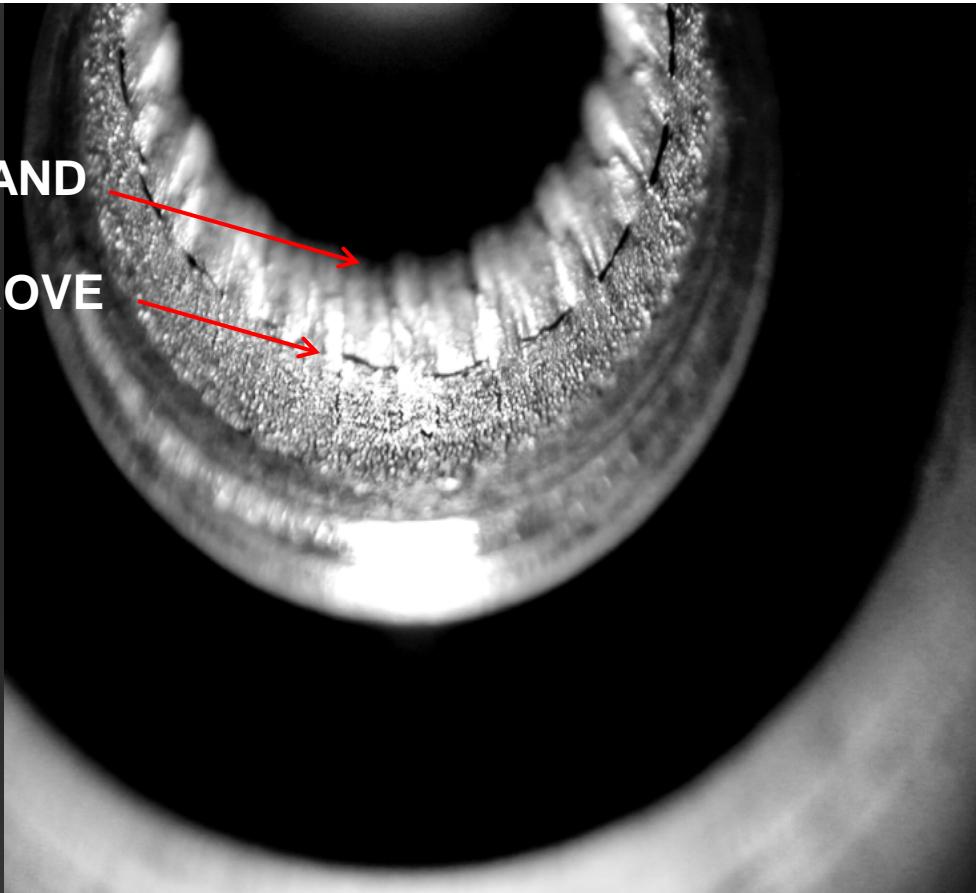
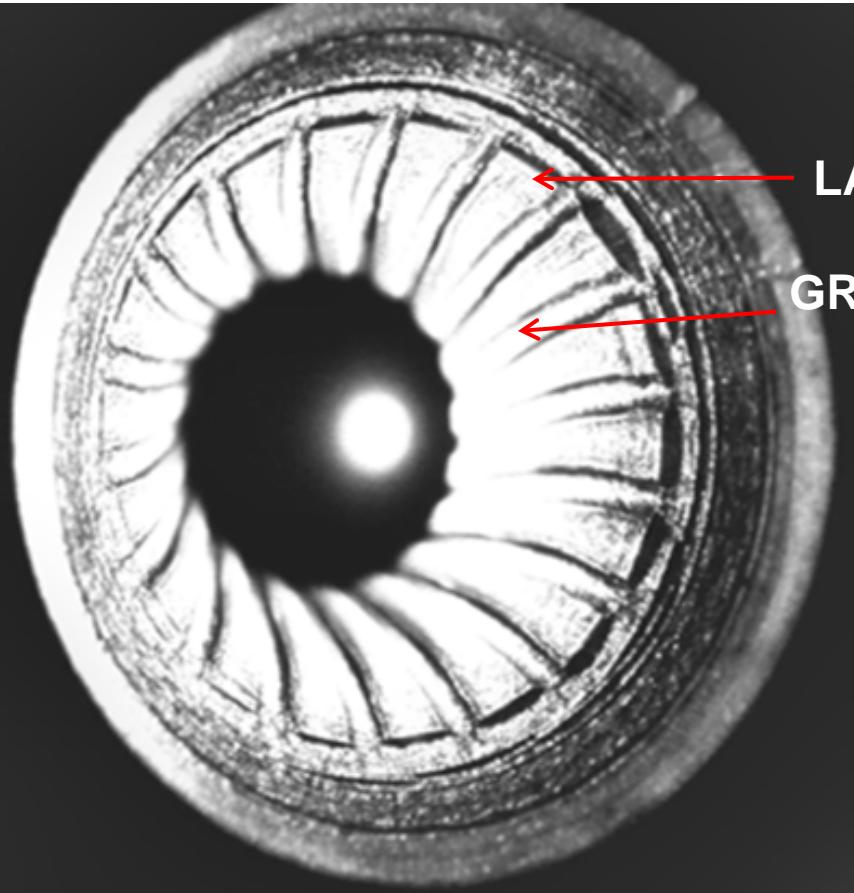


**WORN REGION
BELOW BORE ID
STEEL SURFACE**

Over 12,000+ rounds were fired through SN4 Ta-10W liner.
 The liners: Steel baseline, HC on steel condemned at 3650 rounds.
 The Ta-10W coated steel liner showed little sign of wear or erosion.

Overview of Prior Work

Endurance Testing Results YPG Chamber and Forcing Cone



Ta-10W Eroded 0.270 inch
after 12,000 rounds

Chrome Rifling Eroded 0.700 inch
after 3650 rounds (Condemned)

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Technical Progress

NDT Recording Precision Measurements Over a Weapons Lifecycle



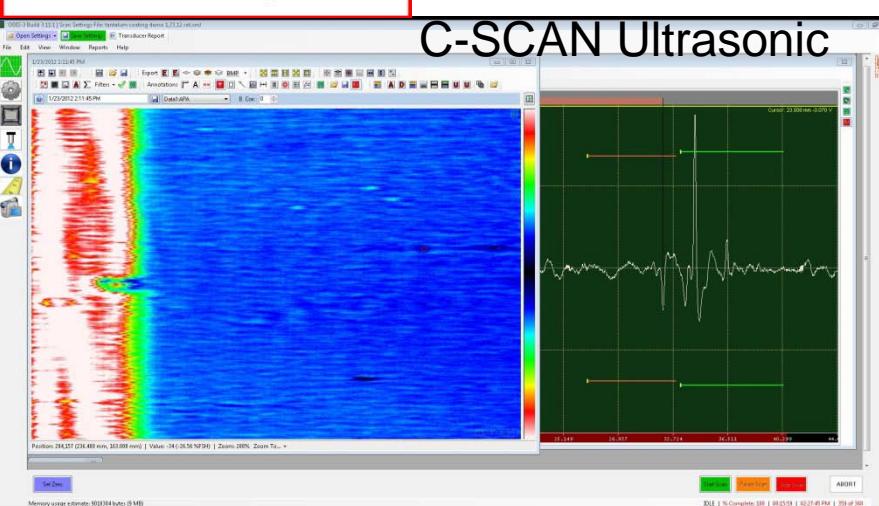
3D Optical Deformational Analysis

ARL-Aberdeen, MD



Faro 3D CMM

C-SCAN Ultrasonic

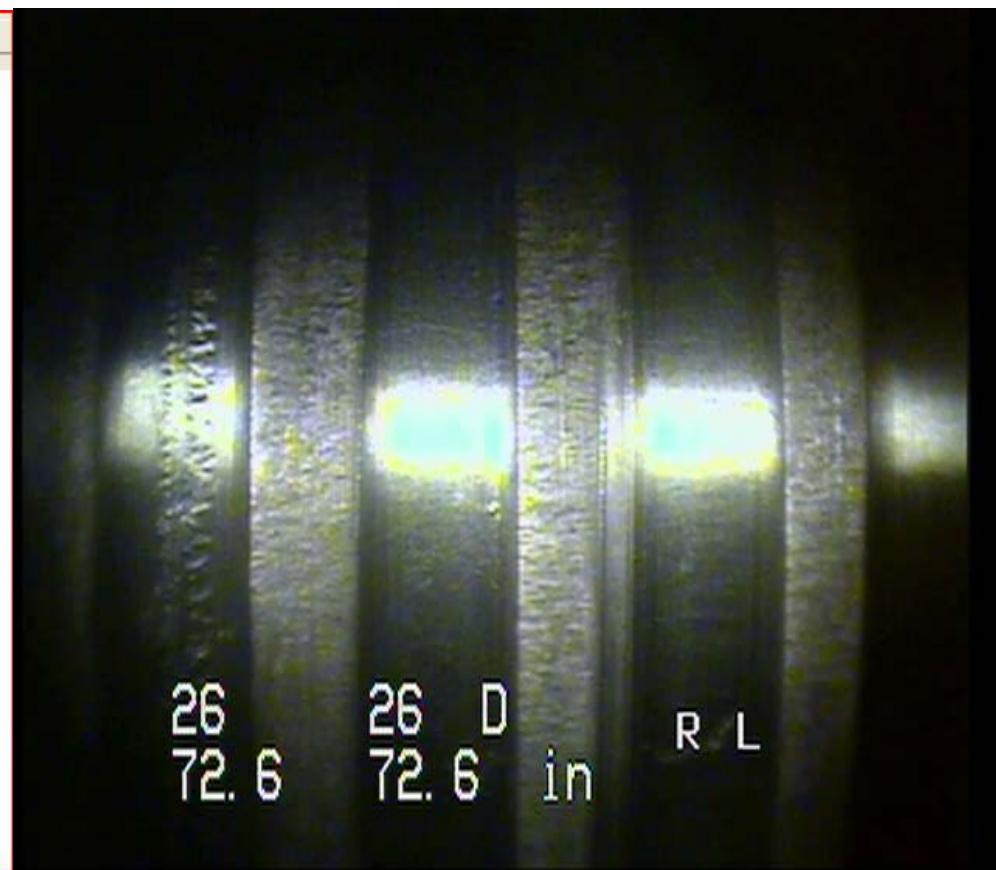
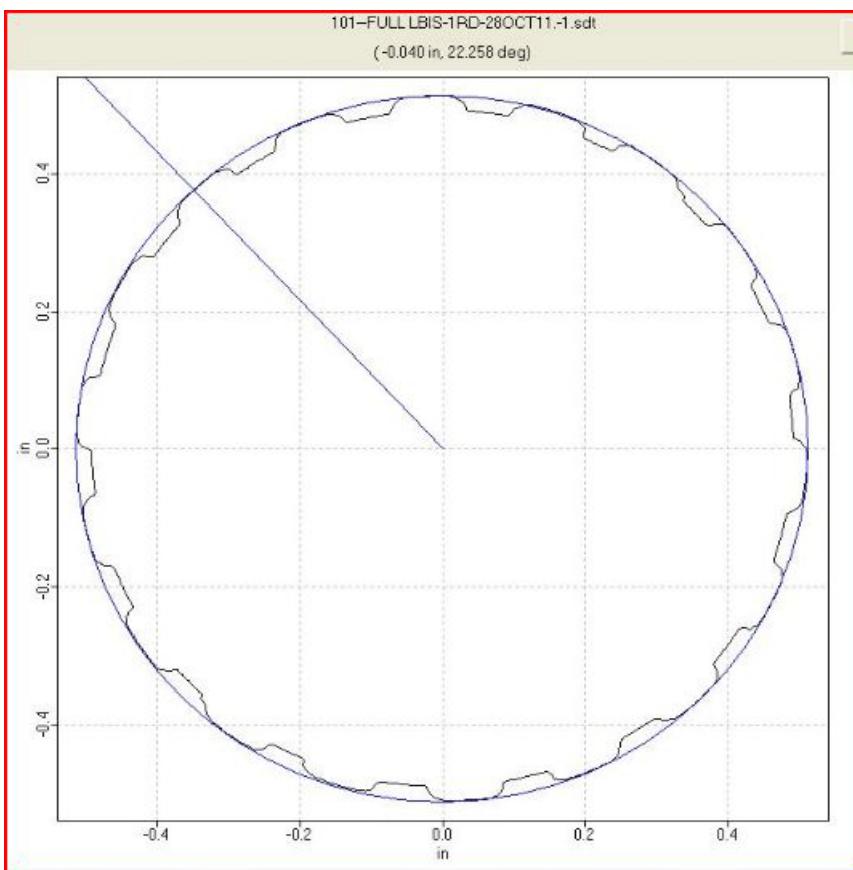


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Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

Pre-Inspection – S/N 101: Ta-10W

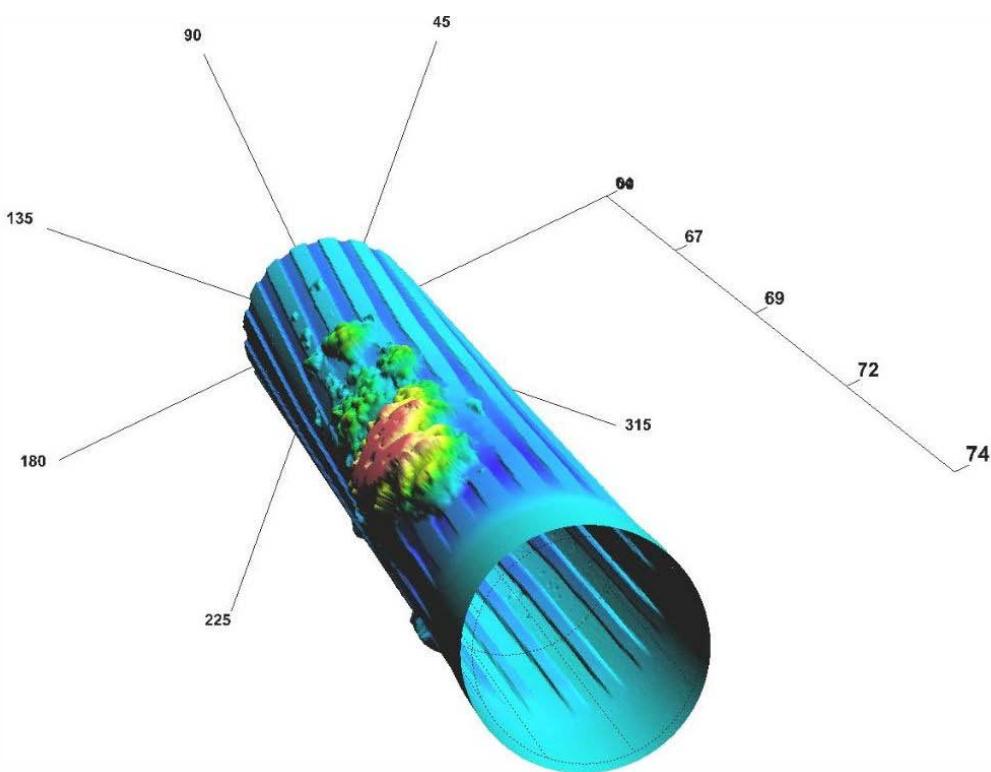


Technical Progress

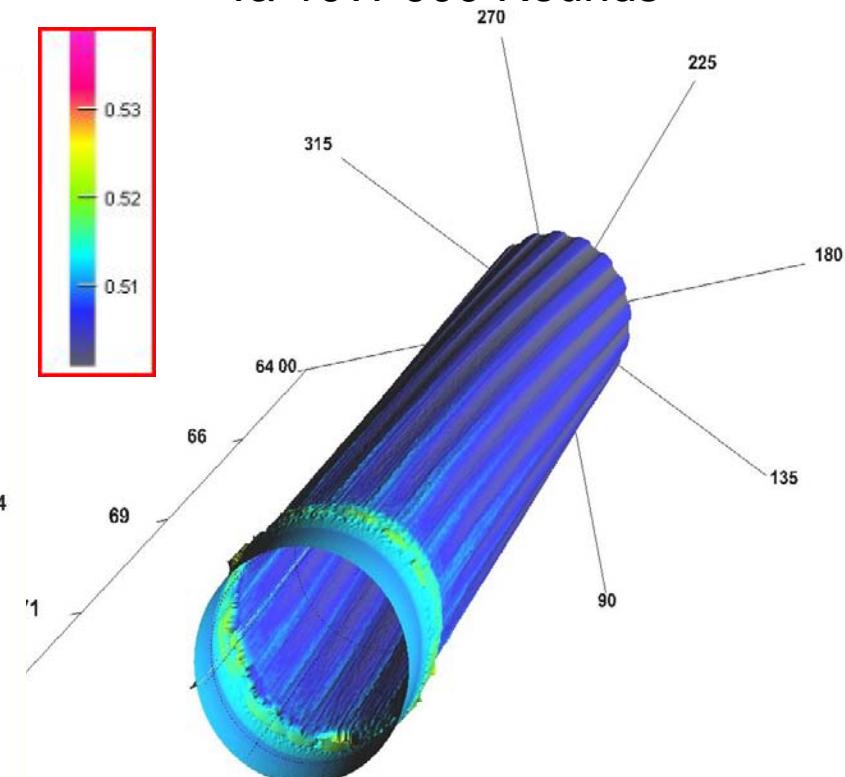
Firing Test Conducted at YPG - High Energy Ammo Tests

1. Visual Observations cont'd,

Chrome Tube 741 Rounds



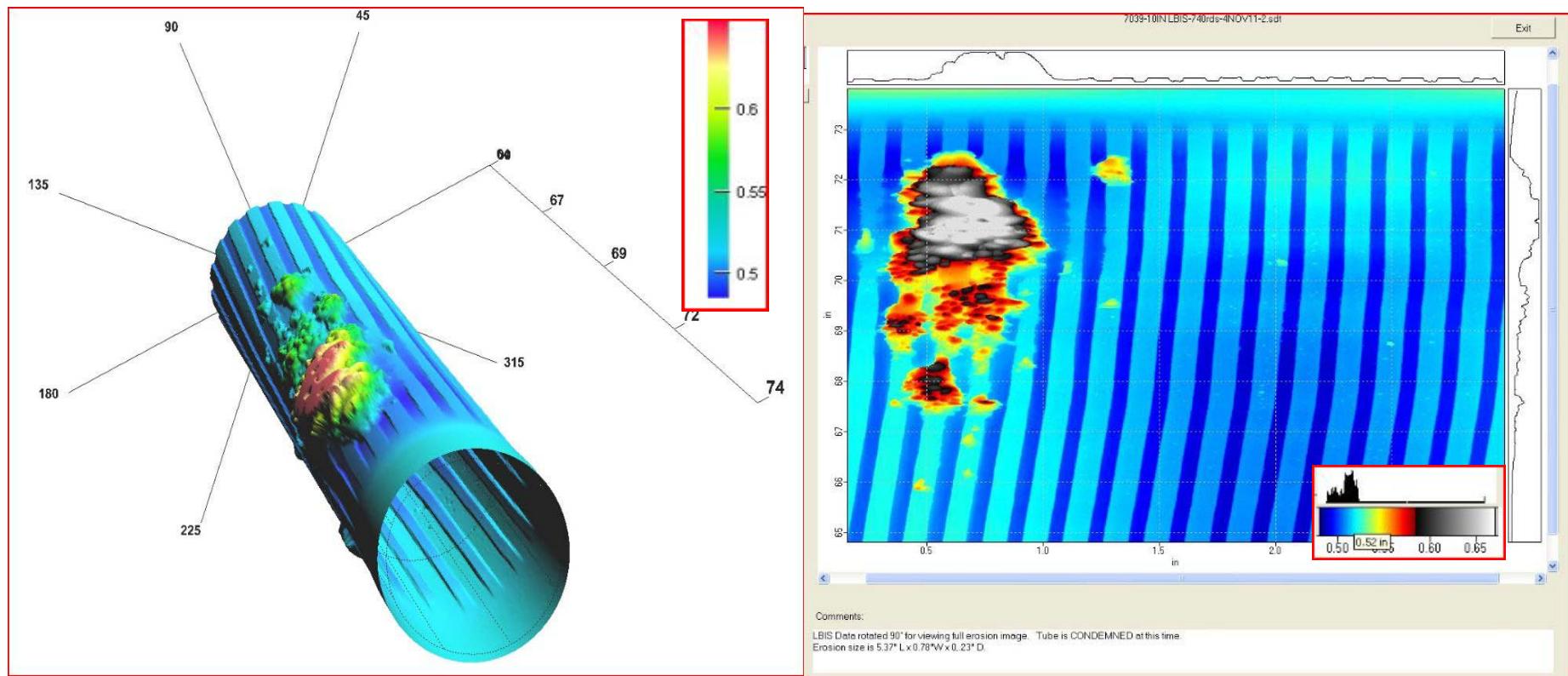
Ta-10W 900 Rounds



Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

1. Visual Observations – Chromium Tube at 740 Rounds



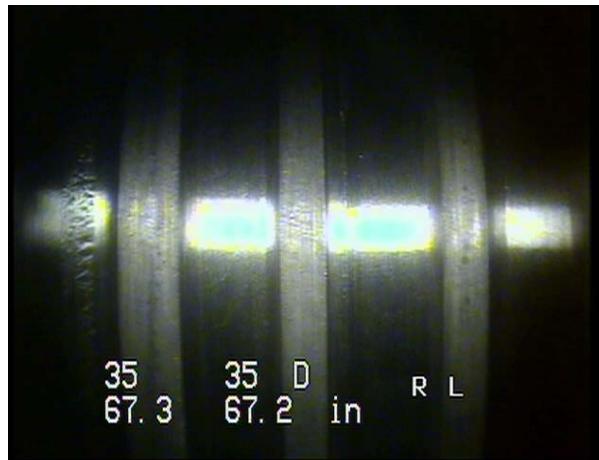
Post Firing - Inspection Catastrophic Failure at 740 rounds

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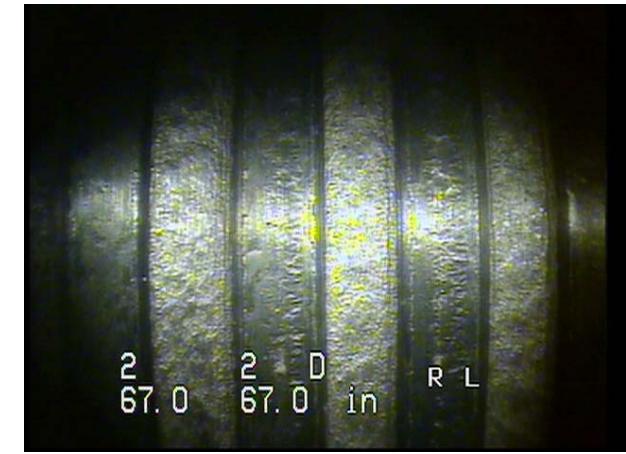
Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

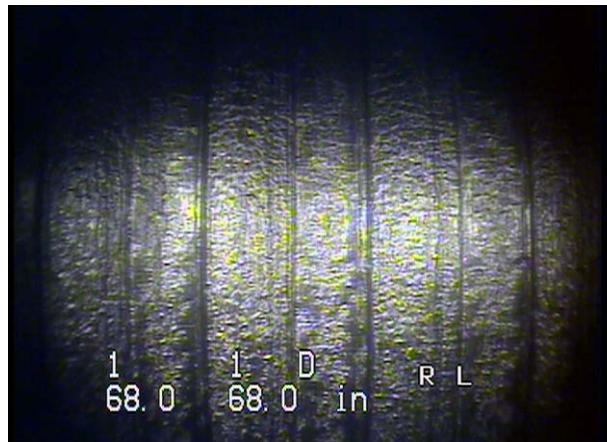
1. Visual Observations cont'd, Ta-10W Tube



1 Round



375 Rounds



750 Rounds



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900 Rounds

Large Caliber Work

Explosive Bonded Liner 105MM



RArefaction waVE guN (RAVEN)

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Technology Transition

- **Potential First DoD Users/Follow-on Implementation**
 - General Dynamics
 - Watervliet Arsenal
- **Responsible DoD/Service Programs**
 - PM CRAM
 - PM Bradley
- **Planned Future Technology Transfer Activities**
 - Leverage PM Support, Demonstrate to PM's
 - Institutional/Regulatory Barriers
 - None Known
- **Process Uses Traditional Metal Working Machinery**
 - No Investment In New Machinery, Buildings or Coating Apparatus



Results

- **Previously Related Demonstrations**

Under SERDP program WP-1426, verified the Explosive Bonding technology

- Explosively Bonded six 12", four 36" truncated 25mm barrels
- Explosively Bonded and test fired two full length M242 25mm barrels

Under ESTCP program WP-101111 verify the robustness of the Explosive Bonding technology

- Fully fabricated four Explosively Bonded full length M242 25mm barrels
- Test fired one barrel using original M919 APFSDS (HES-9053 propellant)

- **Data Summary**

- Initially proof fired M793TP-T projectiles
- Successful testing at YPG was demonstrated using over 12,000 aggressively fired rounds (M793/M791) 200 rounds per minute
- Ta-10W Barrel achieved a round count of three times the current baseline of chrome
- Successful testing at YPG was demonstrated using over 900 aggressively fired rounds (M919 APFSDS) 200 rounds per minute



Innovations

Innovation is realized in:

- The use of **Explosion Bonding** in applying refractory metals in gun barrels
- Use of advanced rifling/metalworking techniques (**Patent Pending**)
- Use of XRAY Tomography for NDT inspection of weapons
- Use of Laser scanner creating a 3D model "cloud of points" of weapon
- Recent Awards
 - **2009 Army Research and Development Achievement (RDA) Award**
EB Bonding and Machining Technologies
 - **2009 Defense Manufacturing Excellence Award** Tantalum Tungsten Cannon Barrel Rifling Technology
 - **2011 Army Science Conference R&E Award**



Questions?

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